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THE APPLICABILITY OF REMOTE SENSING TO THE DETECTION, IDENTIFICATION, AND MONITORING OF POWER TRANSMISSION RIGHT-OF-WAYS WITHIN SELECTED AREAS OF THE TVA REGION

(NASA-CR-135868) THE APPLICABILITY OF REMOTE SENSING TO THE DETECTION, IDENTIFICATION, AND MONITORING OF POWER TRANSMISSION RIGHT-OF-WAYS (East Tennessee State Univ.) ~~14~~ 13 p HC $3.00 CSCL 08B G3/13

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by

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INTRODUCTION

The purpose of this portion of the interpretive phase of the AAG-TVA Remote Sensing Project is to provide examples of the applicability of remote sensing to the detection, identification, and monitoring of power transmission routeways and related phenomena for TVA. Although TVA readily utilizes aerial photography for surveys, the map scales of the photography are large scales of 1:5000 to 1:24,000. Small scale high altitude imagery provided by NASA's RB-57 aircraft and future satellite programs are expected to be of considerable mapping and planning value to many of TVA's divisions and branches. This interpretive phase is primarily being conducted for TVA's Division of Transmission Planning and Engineering for the detection of present power transmission towers, lines, and routeways; ecological conditions; and selected areas for power transmission right-of-way analysis.

PROCEDURE AND METHODOLOGY

The initial procedure for this interpretive phase was to examine the entire coverage of all flight lines of the 9" x 9" color Ektachrome imagery (scale 1:120,000). Each frame was analyzed for the presence of power transmission right-of-ways and power production sites. Each visible transmission right-of-way was counted, then more closely scrutinized with magnification for the detection of small, low reduction phenomena such as towers or transmission lines. From 211 interpreted image frames which contained power transmission related phenomena two examples were chosen for closer observation and mapping (Figure 1).

Standard aerial photographic techniques using a portable light table for illumination and an 8X Agfa Lupe lens, a lighted 4X table mounted magnifier, and a fine scale comparator for magnification and measurements were applied to the interpretive phase of the imagery. Photo maps were made at a 1:1 ratio to the photo scale and thus express the same scale as the imagery, 1:120,000. An attempt was made to photograph several selected frames of the imagery but with little success. However, this led to an experiment in the contact printing of the original color imagery transparencies into reversed black and white prints. The result was a pseudo-negative print which very clearly enhanced the presence of cultural phenomena within vegetated areas and subsequently aided in the detection and presentation of power transmission right-of-ways (Figures 2 and 3).

DETECTION AND ANALYSIS OF SELECTED POWER TRANSMISSION PHENOMENA

Small, Low Resolution Phenomena - Transmission Lines and Towers

The feasibility of detecting and identifying small, low resolution phenomena such as power transmission lines and towers depends upon a myriad of factors: scale of the imagery, size of the feature or features in question, contrast in color and texture between the object and its surroundings, and the factors of film types, cameras and filters, and film processing. Although neither space nor time permit us to analyze each of these factors, the analysis of the imagery yielded noteworthy points regarding some of the factors. The scale of the imagery at 1:120,000 is of small map scale character and consequently for very small objects creates relatively small resolutions. Unquestionably a closer view of perhaps 1:10,000 often provides a better resolution of small phenomena but at the same time negates the large area view which is the desired view of valley-wide phenomena. Although a single scale cannot satisfy everyone's needs (and it should not be expected to) it creates another map view which complements other scales.

The detection of power transmission lines on the 1:120,000 scale imagery (Ektachrome color 9" x 9" format) was almost negligible. Out of 211 image frames and 795 transmission right-of-way sections observed, in only four observations were transmission lines visible to the aided eye. The lines were visible only where they crossed wooded gorges or contrasting water surfaces. In each situation, the identification relied on accompanying surrogate information (i.e., right-of-ways, towers, power sites, etc.). As a point of fact, power transmission lines thus prove to be too small to regularly detect, identify, and monitor on high altitude imagery and would unquestionably be unresolvable from satellite imagery.

The larger object size of power transmission towers enables the interpreter with 1:120,000 scale imagery to detect and identify such objects with surprising regularity. In terms of transmission routeways observed, of the 795 observations, 717 had positively identifiable towers. Without magnification only 175 observations of the 795 could be identified as having towers.

Although this analysis was designed to test the feasibility of detecting transmission towers, it further tested the reliability of magnified vs. non-magnified observations. Because of the small image size of the transmission tower, magnification was almost entirely required. However, when compared to the detection of transmission lines, the ease with which towers could be detected with magnification was a positive endorsement to the high altitude imagery scale.

As for monitoring the condition of towers with the aid of high altitude imagery, I cannot recommend it. Although towers are discernible, their components are not. Only if a tower were toppled could one detect a change in its image characteristics and this condition could be far easier detected by telephone complaints reporting power failure.

In those cases in which transmission towers were undetectable, the problem was an inability to detect towers on cleared farmland. Thus surrogate information such as right-of-way swaths in forested areas and power sites became necessary for reliable tower detection and identification.

Large Scale, Higher Resolution Phenomena - Right-of-ways, and Power Production Sites

The power transmission feature which probably first attracts the eye of the photo interpreter is the transmission right-of-way. In forested regions, it appears as a straight swath of cleared, deforested ground approximately 100 to 200 feet wide and extending for miles across the landscape. It is worthy of considerable study alone, but more than that, the transmission right-of-way is a surrogate for towers and lines and geographically leads to the location of power sites and substations. Because of the relative expanse of forest lands in the total study area, the detection of power transmission routes was favorable. Although the right-of-ways are easily detected in forested or vegetated areas because of the cleared swaths, they are not readily seen on plowed or cleared farmland. Thus the cleared swath of the right-of-way becomes the photo signature.

A distinction should be made between power transmission right-of-ways and gas line right-of-ways. Whereas the two features may appear in the same forested area, the power transmission swaths are straighter and wider than most gas line swaths. Furthermore, the power route has transmission towers and service roads within the swath which the gas line routes do not. Finally, in the swath and on cleared farmland the buried gas line can be distinguished by soil coloration differences and minute topographic irregularities (i.e., surface roughness).

The monitoring of present transmission right-of-ways is highly feasible with high altitude aircraft imagery. Vegetative cover and cleared conditions within the right-of-way swaths are easily distinguishable. Although relative tree height may be more difficult to accurately measure from the small scale imagery, the observer can certainly detect for a monitoring capability, changes in the ecological (vegetated vs. non-vegetated vs. erosional) conditions of the right-of-way. From this information then, environmental as well as equipment monitoring may be achieved by conducting periodic overflights of right-of-way areas.

From the imagery,of the 795 right-of-way observations, 17 exhibited noticeably cleared (non-vegetated conditions within the swaths. They were located in: (1) the western portion of the Valley in the vicinity of Paris, Tennessee and Murray, Kentucky, (2) the Johnsonville Steam Plant area, and (3) the vicinity of Oak Ridge and the Kingston Steam Plant.

Because it is a regular procedure to revegetate the right-of-way swaths,the problem of soil erosion should not conceivably loom great. In no instance did an example of severe soil erosion appear within the observed swaths of the study area.

The detection and identification of power generation installations was made relatively easy because of their large image size. Hydroelectric power sites are unquestionably the easiest to identify as a result of their reservoirs, dams, switchyards, and transmission routes. Steam plants are likewise easily identified because of the plant buildings, switchyards, and especially the transmission right-of-ways. Surrogate information from the presence of transmission right-of-ways radiating out from the steam plants distinguish them from industrial plants on the imagery.

The feasibility of monitoring power generation plants depends upon what components require a monitoring function. Unlike power transmission route swaths through forest lands, power plants do not necessarily change in a visual way. If any changes do take place they are already known internally with the number of ground personnel monitoring conditions at the site itself. The monitoring function of aircraft imagery is thus much more applicable to power phenomena remotely located beyond the ground monitoring capability of TVA personnel.

SELECTED EXAMPLES OF POWER TRANSMISSION PHENOMENA

Colbert Steam Plant Transmission Lines - Colbert and Franklin Counties, Alabama

The photograph in figure two best represents the nature of power transmission right-of-ways in terms of their landscape expression. The right-of-ways here labelled E1-5 are located south of the Colbert Steam Plant and northwest of Russelville, Alabama. Within the image are other linear features which could be mistaken for power right-of-ways. The irregularly lineated gas pipeline right-of-way and the railroad in the center of the photograph are cases in point.

Details of the power transmission right-of-ways reveal several distinctive characteristics. Although transmission lines and towers are not visible on this negative print, on the original color transparency, the towers can be seen through the use of magnification. Furthermore, the substation, appearing in the upper right portion of the image, revealed on the original transparency six banks of transformers.

The width of power transmission right-of-ways often indicates the relative amount of kv's being transmitted. Right of ways E-1, E-2, E-3, and E-5 are 100-150 feet wide and, as verified by TVA maps carry 161 kv. Right of way E-4, which is part of an electric cooperative, measures 75-100 feet wide and carries 46 kv.

Johnsonville Steam Plant

The photograph in figure three represents a power generation site and its related power transmission switchyards, and right-of-ways. The steam plant, located at the center of the photograph, transmits power out on 14 right-of-ways. The larger right-of-ways nearer the east side of the plant transmit power on eight routes that collectively occupy a swath which is 1180 feet wide (A). Among these are two 500 kv routes, one of which serves the Nashville area. The other, newer 500 kv route, is directed toward the Cumberland Steam Plant to the northeast.

Serving the area west of the Tennessee River, six right-of-ways occupy a swath of 850 feet width (B). Within this area are two 500 kv routes which service the Memphis area.

Although transmission lines are not visible here, several of the right-of-ways have visible towers in them. Most noticeably are the tower placements in the upper left portion of the photograph in the new 500 kv right-of-way.

Swath widths for individual right-of-ways vary from 75 to 200 feet. The larger width routes (150-200 feet) which normally carry 500 kv are located at E-1, E-2, and E-3 and E-4. With the exception of the smallest swaths, all others measure 100'-125' wide and are 161 kv transmission routes.

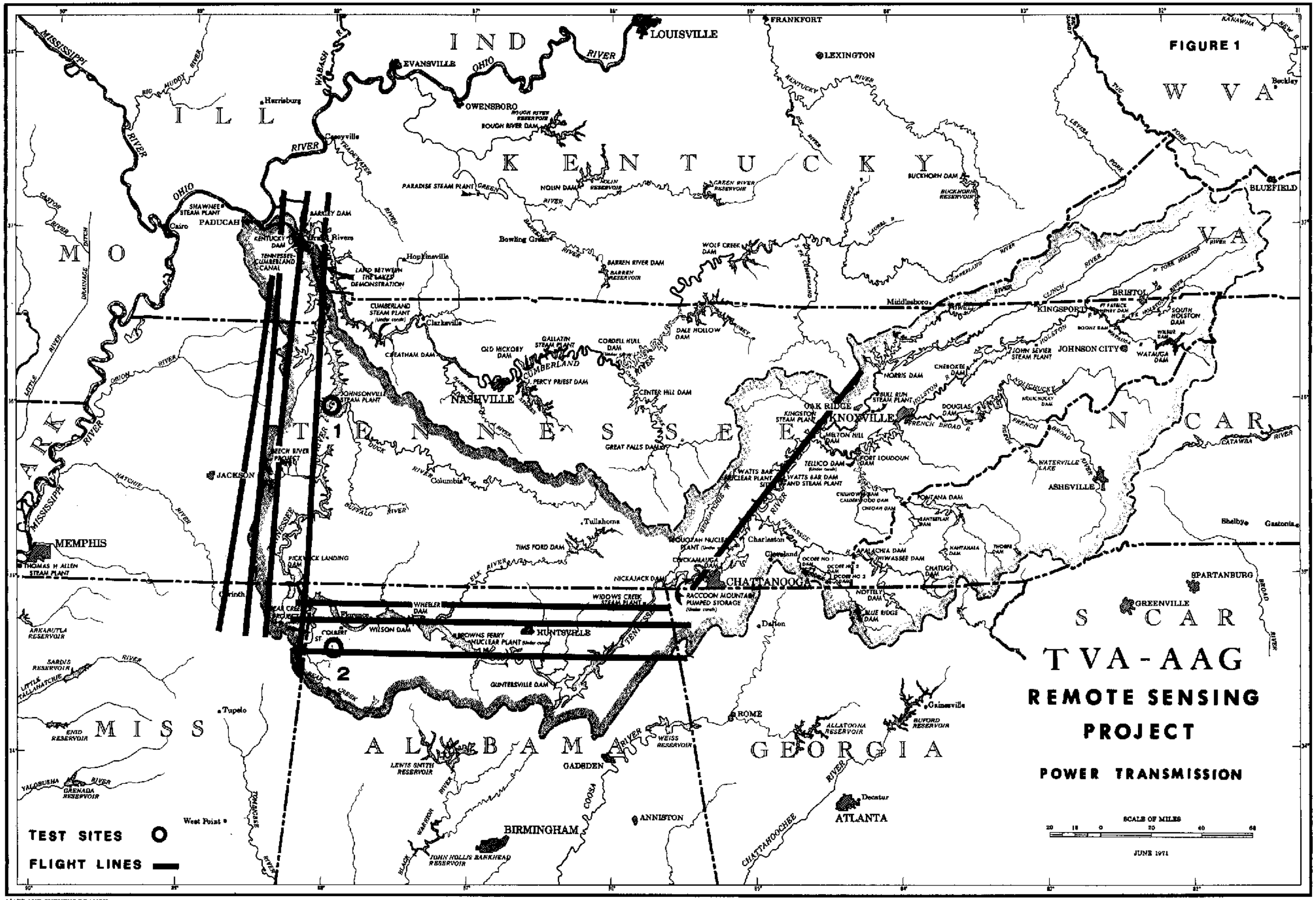
Conclusion

The final point to be made here in the feasibility of high altitude imagery for the analysis of power transmission phenomenon is to show that not only some details can be seen but more importantly, that a larger area-wide perspective can be reached through this medium. In each individual photograph, the North-South distance measures 17 miles, the East-West distance is 15 miles for the print photos and 17 miles for the original transparencies. The total area covered by the photographic prints is 255 square miles. With a photo area of this magnitude and with corresponding imagery from lower altitudes for details and satellite photos for the broader perspective, (10,000 square miles) the interpreter and the user agency are best served in the detection, identification, monitoring, and planning of power transmission phenomena (Table 1).

TABLE I

Feasibility of Detecting, Identifying, and Monitoring of Power Transmission Phenomena from High Altitude Aircraft Imagery

Object	Detection	Identification	Monitoring	Planning
Power Lines	Poor	Poor	Impossible	-
Power Transmission Towers	Good	Fair	Poor	Good
Power Transmission Right-of-ways	Good	Good	Good	Good
Power Substations	Good	Good	Fair	Good
Power Generation Sites	Good	Good	Fair	Good



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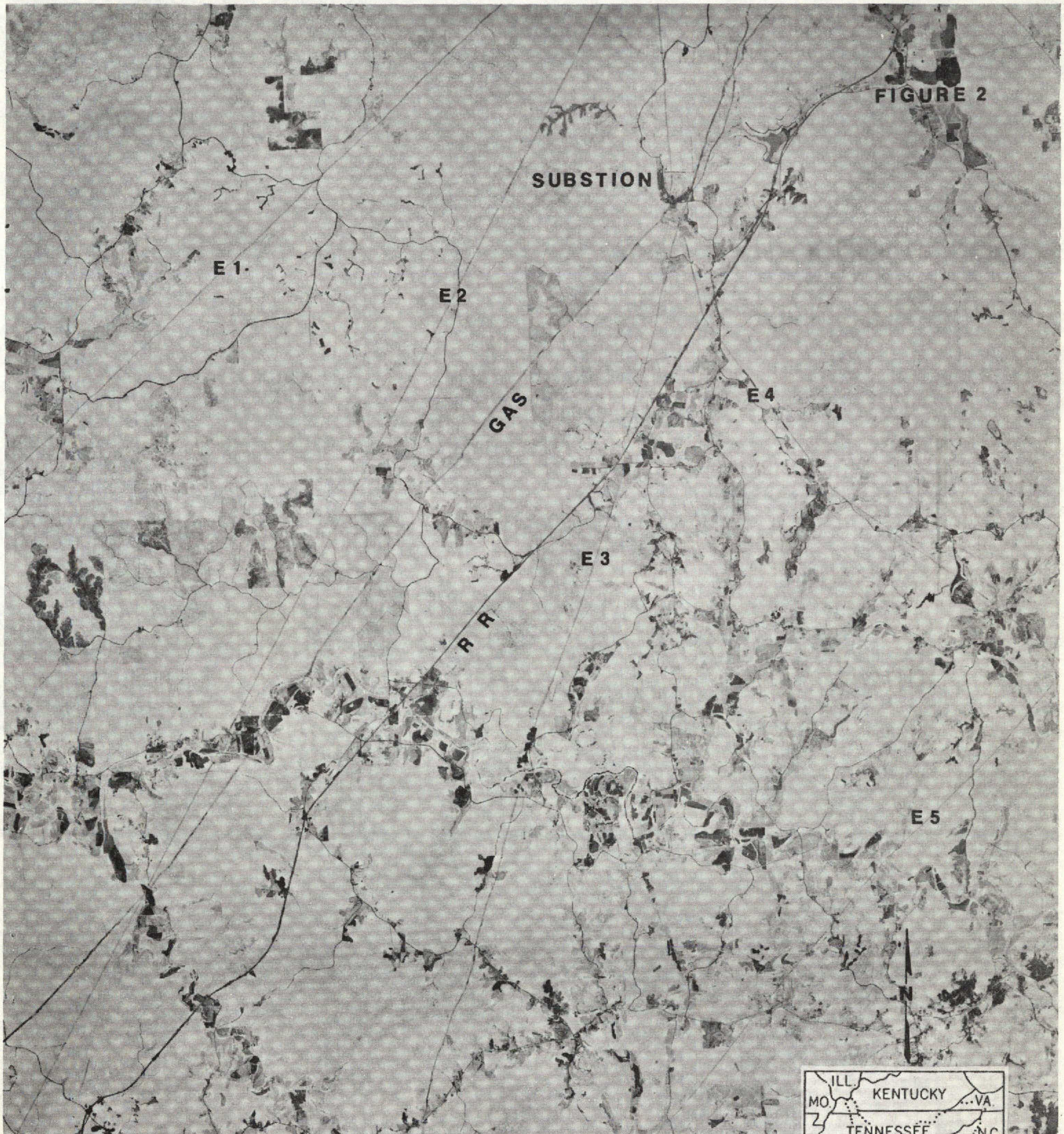
FIGURE 2
SUBSTION
E1
E2
GAS
E4
E3
R R
E5
N
ILL.
MO.
KENTUCKY
VA.
TENNESSEE
N.C.
MISS.
ALA.
GA.
S.C.


E 2
E 1
A
B
JOHNSONVILLE
STEAM PLANT
E 3
E 4
N
ILL.
KENTUCKY
MO.
VA.
TENNESSEE
N.C.
MISS.
ALA.
GA.
S.C.

FIGURE 3